SIMULATION TEST OF AUTOMOTIVE INTAKE VALVE USING COMPUTER AIDED ENGINEERING SOFTWARE

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ABSTRACT

Analysis of stress with different material in intake valve is the main purpose of this project. This research was carried about the stress impact in intake valve head where the most wear would occur at particular different RPM. The study of this thesis is based on previous research in intake valve stress and fatigue by experiment. Without actual experiment, intake valve stress can be analyzing by simulation using ALGOR software and specific RPM with specific maximum cylinder pressure can be calculated via GT-POWER software. Three most common intake valve materials was tested to be compared between stress which are common steel intake valve material, ceramic intake valve material and titanium alloy intake valve material. The best material for intake valve within the three material tested would be titanium alloy intake valve. Titanium alloy material properties shown a very low impact of Von Mises Stress 173.6537 Mpa compared to ceramic intake valve 184.1683 Mpa and steel intake valve 179.0992 Mpa at the constant given load 16614.9411 N in 2000 RPM and temperature 300^{o}C. The stress effect at intake valve seat showed the highest stress impact of Von Mises Stress at all intake valve material. It also shown a possible of wear happened in a form of ring around intake valve seat.

ABSTRAK

Analisa mengenai tekanan pada injap masuk injin adalah tujuan utama projek ini. Kajian ini dibuat mengenai tekanan terhadap kepala injap masuk dimana kehausan dijangkakan berlaku pada putaran injin yang berbeza. Informasi mengenai tesis ini adalah berpandukan kajian terdahulu mengenai tekanan injap masuk dan kejerihan injap masuk. Tanpa experimen, tekanan di injap masuk boleh dianalisa menggunakan perisian ALGOR FEMPRO dan puncak tekanan didalam silinder dapat dicari menggunakan perisian GT-POWER. Tiga bahan injap masuk yang lazim digunakan telah diuji dan dibandingkan tekanannya iaitu injap masuk yang terdiri daripada injap masuk keluli tahan cacat, injap masuk seramik, dan injap masuk campuran titanium. Bahan injap masuk yang terbaik ialah dari campuran titanium. Bahan dari campuran titanium menunjukkan kesan terendah terhadap tekanan Von Mises Stress iaitu cuma 173.6537 Mpa jika dibandingkan dengan injap masuk seramik 184.1683 Mpa dan injap masuk keluli tahan cacat 179.0992 Mpa berdasarkan beban 16614.9411 N dan suhu 300^{o}C. Kesan tekanan terhadap bahagian *seat* injap masuk menunjukkan kesan tekanan Von Mises yang tertinggi kepada semua jenis bahan. Ia juga menunjukkan kemungkinan kehausan berlaku dalam bentuk cincin sekeliling *seat* injap masuk.

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%	percentages
B	bore
D	diameter
L	lift
R	fillet radius
Ø	cone angle
Ψ	seat angle

LIST OF ABBREVIATION

BDC	Bottom Dead Center
CAD	Computational Aided Design
CAE	Computer Aided Engineering
TDC	Top Dead Center
3D	Three Dimensional
kPa	Kilo Pascal
mm	millimeter
RPM	Revolution per minute
FEA	Finite element analysis

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CHAPTER 1

INTRODUCTION

1.0 General Overview

On 3cylinder 4-stroke engine like the Daihatsu 660 used in Perodua Kancil there is a process of combustion process. This occur during the power stoke where air-fuel mixture been ignite by sparks plug and combust pushing the piston down to bottom depth center.

The combustion process in the engine producing high pressure and load affect the combustion chamber which include intake valve head and exhaust valve head in certain range of maximum pressure and temperature. At maximum combustion load in the intake valve seat and intake valve head would damage the valve if the valve material is not chosen properly. High stress impact on the valve head could course valve wear and the valve might be not tightly close.

So to improve the stress impact different material can be choose as different material have their specific ultimate tensile strength that can stand again stress at different loading impact. The material chosen for intake valve must also withstand temperature about 300^{o}C. In order to investigate the combustion chamber stress impact on intake valve head some variable must be put constant. The temperature and design of the intake valve is been set constant as the loading impact is increase according to specific RPM and specific maximum combustion chamber pressure for the Daihatsu 3 cylinder 4-stroke engine.

The best way to investigate and test the stress impact on intake valve head is by using simulation via computer aided engineering software. ALGOR Fempro is the best software available to investigate stress analysis. Three different intake valve materials can also be selected using ALGOR software. The GT-POWER software can provide the information of maximum combustion chamber at different RPM.

1.2 Problem Statement

Nowadays the performance of engine is depends on the valve train instability which limits the engine speed. Component breakage and excessive wear will occur in the valve train if it is operated in an unstable mode. The major component of valve train instability is the valve weight itself. Different material would course different valve weight, stress impact and life cycle of an intake valve.

However, to analyze the stress impact on intake valve there are several parameter that need to be considered. The parameter is the material for intake valve must have high ultimate tensile strength as intake valve experienced high cylinder pressure and high temperature during combustion process. Three material selected are tested in ALGOR software and compared between Von Mises Stress. The best material out of three selected material is to be choose.

1.3 Project Objective

Basically the main purpose in accomplishing this task are stated below

i. To investigate the stress in intake valve using CAE software.

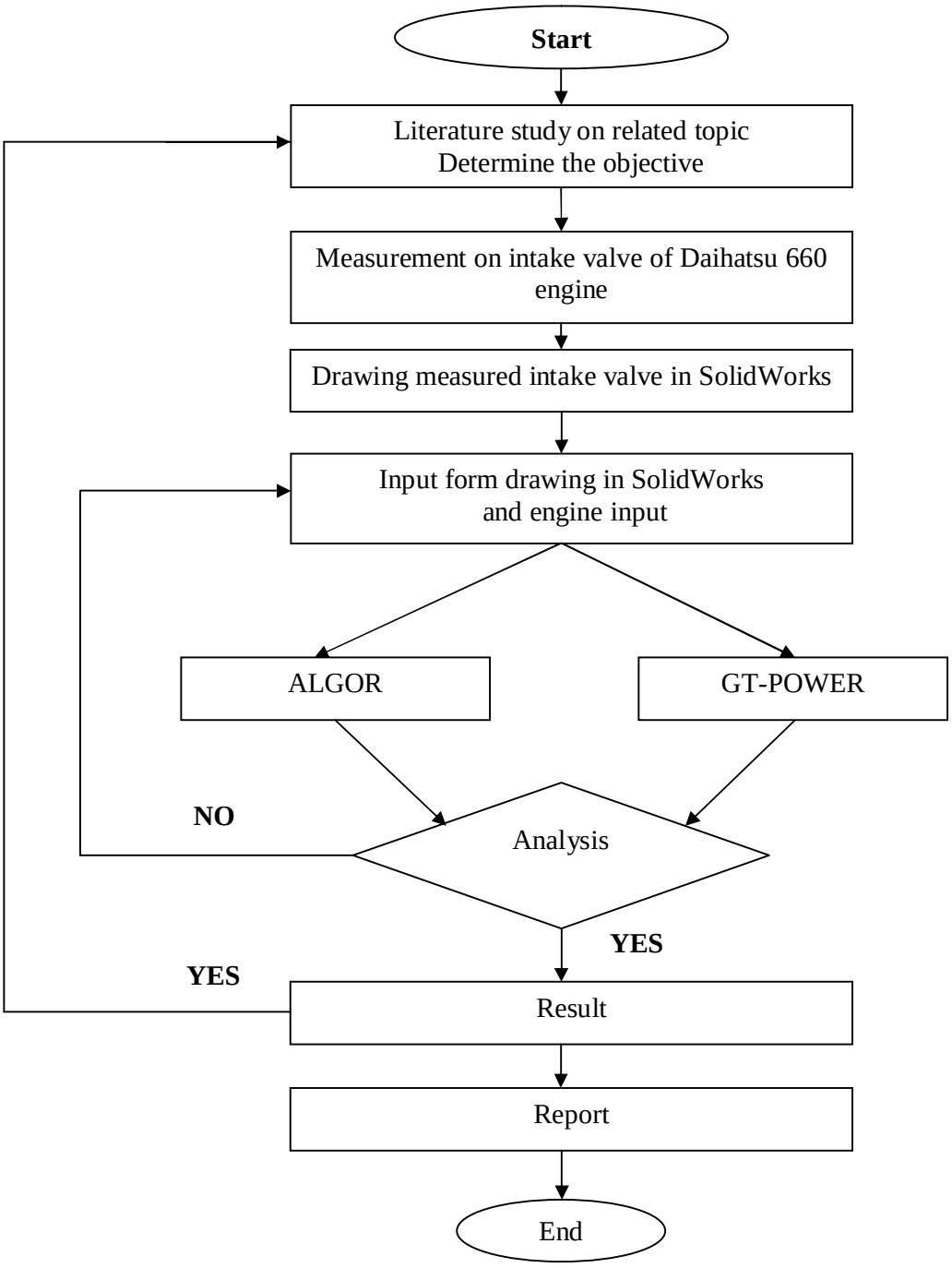
ii. To compare the maximum stress between 3 different material of intake valve.

1.4 Scope of Project

The scope of this project is focusing on the criteria that stated below

i. The most common intake valve for engine below 1.6cc is chosen
ii. Combustion chamber effect in intake valve head was considered
iii. 3 most common intake valve materials were chosen.
iv. Only static stress analysis with different material model using CAE software was considered.

1.5 Flow Chart of This Project



CHAPTER 2

LITERATURE REVIEW

2.1 Combustion Fundamental in Four stroke engine

Four stroke engine also known as Otto Cycle because The German engineer Dr. Nikolaus August Otto (b. June 10, 1832 - d. January 26, 1891) developed the four-stroke internal-combustion engine, which offered the first practical alternative to the steam engine as a power source [1]. On four stroke engines there are four phases of operation per cycle, each corresponding to an upward or downward stroke of a piston [3]. The detail of each phase within the four stroke engine is as follows:

2.1.1. Intake stroke ; on this stoke it will begin with the piston in Top Dead Center (TDC) position during the piston goes downward the fresh air- fuel mixture was drawn into the cylinder and finished at Bottom Dead Center (BDC) [2].During this phase the intake was start open 12 degree before TDC and its still remain for 56 degree past BDC after this stroke ends this to give more air fuel mixture to flow into the cylinder [3].

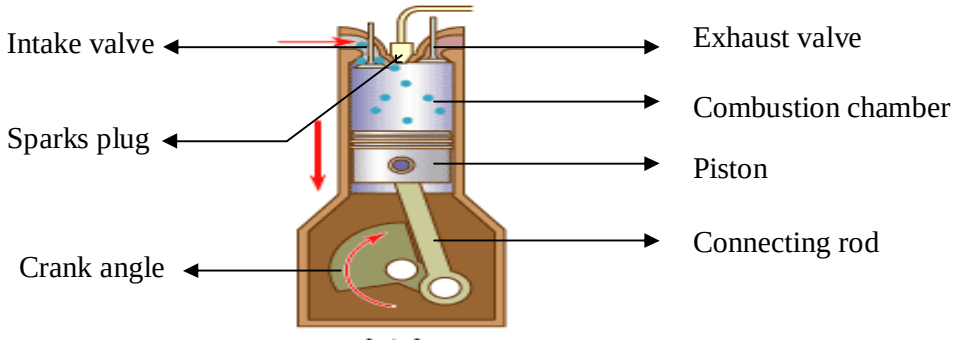


Figure 2.1 Intake stroke [6]

2.1.2. Compression Stroke; for this stroke the both valve was close and the piston moves back to TDC. During the moves of piston upward the fresh air-fuel mixture was compress until the TDC then the spark is induce which is to initiate combustion and the pressure in cylinder rises during this combustion process [3].

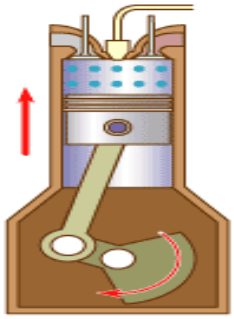


Figure 2.2 Compression stroke [6]

2.1.3. Power Stroke ; it is also known as expansion stroke, in this stroke the piston goes downward to BDC and drives the cranks of the engine to give power to the drive train. The fact that it happen because during the combustion process the pressure rapidly increase that push the piston to goes downward [3].

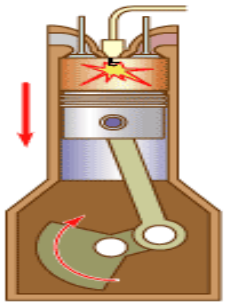


Figure 2.3 Power strokes [6]

2.1.4. Exhaust stroke ; This is when the gas burn from the power stroke was bring out from cylinder trough the exhaust valve because the cylinder pressure is higher than exhaust port pressure. At this stroke the valve start open at 47 degree before BDC on the power stroke this is for give more time for the exhaust gases to leave the cylinder [3].

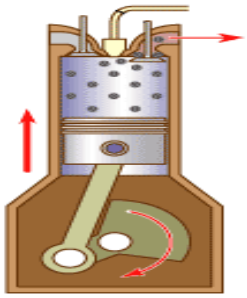


Figure 2.4 Exhaust strokes [6]

During this four stroke engine phase there is occur gas exchange in the intake and exhaust stroke. The gas exchange process will be discussed in the new sub topic.

2.2 Gas Exchange Process

The gas exchange process occurs on intake and exhaust stroke. The purpose of intake is to admit the fresh charge for the next cycle and for the exhaust is to remove the burned gases at the end of the power stroke [1]. The indicate power of an internal combustion engine at given speed is proportional to the mass flow rate.

During this process there is subsystem that should be consider like intake and exhaust manifold, intake and exhaust port and valve lift and geometric design. All of this system could give an effect to this process. Because, if the process not work sufficiently the performance of engine will decrease because of the charging and expelling the fuel and gases not flow properly. So it will influence the volumetric efficiency when charging the fresh fuel.

During the exhaust process, the gas exchange process is to retaining the mass of the fuel to flow into the cylinder so the pressures on the cylinder not reduce. This higher pressure in exhaust process is needed to fully expel the burn gases to prevent it from producing the emission.

The primary goal of the gas exchange process are the inducting maximum air mass at the wide-open throttle or full load and retaining that mass within the cylinder [1].

2.3 Exhaust Process

Exhaust process is to expel the burned gases from the cylinder to the exhaust manifold. This process consist two steps blow down and exhaust stroke .During the exhaust valve open near the end of the expansion stroke the high temperature gases suddenly subjected to a pressure decrease as the resulting blow down occur [5].

A large percentage of gases leave the combustion chamber during the blow down process that was driven by the differential across the open exhaust valve. But there is still had exhaust gases at the cylinder.

The gases then pushed out from the cylinder trough the valve when the valve exhaust still open by the piston that travels from Bottom Dead Center (BDC) to Top Dead Center (TDC) during the exhaust stroke.

During the blow down process the gas leaving the combustion chamber by it kinetic energy due to high velocity flow trough the exhaust valve. But at the end of the process there is still a residual gas trapped in the clearance volume on the cylinder [5].

Therefore, there is losing power during through back pressure. The exhaust valve opens at the beginning of the exhaust stroke, and then the piston pushes the exhaust gases out of the cylinder. If there is any amount of resistance that the piston has to push against to force the exhaust gases out, power is wasted. Using two exhaust valves rather than one improves the flow by making the hole that the exhaust gases travel through larger.

The residual gas will mixed with the new incoming charge of air and fuel is carried out during the intake process [5].

2.4 Intake Process

Intake process is the system that to deliver the proper amount of air and fuel into the cylinder with right accuracy and equally to all cylinders at the proper time in engine cycle [5].

On this process consist intake manifold, throttle, intake valve and either fuel injector or carburetor to add fuel [5] and during the induction process it will flow trough to this component system.

During this process the pressure drop in the intake system is depends on engine speed the flow resistance of the element in the system and the cross sectional area for charge the fresh air fuel mixture through the valve. In usually practice to improve the charging for intake and emptying for exhaust stroke in cylinder and make the best inertia of gases in both stroke by extend the valve open phase beyond the intake and exhaust stroke [1].

In intake manifold, inside the diameter of the runner must be large enough to reduce high flow resistance through inlet valve and increase the volumetric efficiency.

2.5 Volumetric Efficiency

Volumetric efficiency is a ratio (or percentage) of what volume of fuel and air actually enters the cylinder during induction to the actual capacity of the cylinder under static conditions. Besides that volumetric efficiency is used as an overall measure of the effectiveness of four stroke cycle engines and its intake and exhaust system as an air pumping device [1]. It is desirable to have maximum volumetric efficiency in the intake of any engine [5].

There are many physical and operating variables that could affect the volumetric efficiency. One of it is closing intake valve after BDC .It was the timing of closure the intake valve that could affect the amount of air enter the cylinder.

When intake valve is open and the piston is moving from TDC to BDC. The air was pushed into the cylinder trough the open valve due to create vacuum by the additional volume being displaced by the piston [5].

There is a pressure drop in the air when it passes through the intake valve and the pressure in the cylinder is less than the manifold pressure. This different pressure is to allow the air to enter the cylinder by flow through the valve.

2.6 Types of Valves

A valve is a mechanical device that is used to control the volume of flow and pressure of fluids. Closing, opening, or partially opening a passage through which the fluid passes regulates this flow. Valves are used in areas of commercial applications, domestic and process applications, automobiles, hydraulic presses, medical equipment and many more.

There is a lot of type valve design. Many of these valves serve to control the pressure of fluids and are known as pressure-control valves. There is a lot of type of valve and it can identified by it names and use. Below is the type of valve and the usage.

i. Butterfly Valves have circular plates attached to a shaft resembling wings of butterfly, hence the name. The shaft has a handle that can be turned so that the wings obstruct the water passage. The wings are immersed in the water and this causes a pressure drop. These valves are used in water supply systems for flow control.

ii. Gate Valves are used in process industries for full open or full close systems. It has a rectangular or round gate fitted to a stem, which is enclosed in a